HOST STATUS OF MAMEY SAPOTE TO CARIBBEAN FRUIT FLY (DIPTERA: TEPHRITIDAE)

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ABSTRACT

Field trapping of *Anastrepha suspensa* (Loew) in groves of mamey sapote, *Pouteria sapota* (Jacq.), showed that fly populations were present in high numbers in all of the groves used for the experiments. Fly populations were highest at the beginning and end of the sampling period. More than 646 fruit of mamey sapote weighing a total of 459.9 kg were exposed to Caribbean fruit flies either in the laboratory or under natural conditions. In one test in the laboratory, 9 Caribbean fruit fly larvae were recovered from mamey sapote fruit. All of the control guava fruit had infestations, some as high as 70 larvae per fruit. In the field tests, no mamey sapote had infestations of Caribbean fruit flies, either naturally occurring or from caged infestation tests. Pressure measurements showed that mamey sapotes averaged -80 to -130 Newtons which is much harder than guavas which averaged -30 Newtons. Magaña and Pantin mamey sapote collected in the field in Florida were not found to be hosts to the Caribbean fruit fly, but laboratory infestation was found to occur.

Key Words: *Pouteria sapota*, *Anastrepha suspensa*, host status, quarantine

RESUMEN

La captura en el campo de *Anastrepha suspensa* (Loew) en arboledas de mamey zapote, *Pouteria sapota* (Jacq.), demostraron que populaciones estaban presentes el altas cantidades en todas las arboledas usadas para los experimentos. Populaciones de mosca fueron mas altas al comienzo y al terminar del periodo de muestreo. Mas de 646 frutas de mamey zapote pesando 459.9 Kg. fueron expuestas a la mosca de fruta del Caribe ya sea en el laboratorio o bajo condiciones naturales. En una prueba en el laboratorio, pocas cantidades de larvas de mosca del Caribe fueron recuperadas de frutas de mamey zapote. Todas las frutas control de guayaba tuvieron infestaciones, algunas tan altas como 70 larvas por fruta. En pruebas de campo, no hubo infestaciones de mosca del Caribe en mamey zapote, ya sea en condiciones naturales o en pruebas de infestación en jaula. Medidas de presión demostraron que mamey sapotes son mucho mas duros que guayabas. Las variedades de mamey zapote Magaña y Pantin, criadas comercialmente en la Florida, no son hospedantes de la mosca de fruta del Caribe.

The mamey or mamey sapote, *Pouteria sapota* (Jacq.), is a fruit tree in the family Sapotaceae native to Central and South America (Morton 1987). The fruit are large, up to several kg, with a salmon pink, orange, to deep red flesh and a large central seed. The dark brown skin or rind is very tough and resistant to puncture or damage, particularly in unripe fruit. The mamey sapote is grown commercially on a small acreage (108 ha) in South Florida with an estimated annual value of $1.5 million (Balerdi et al. 1996; Lamberts & Crane 1990).

The Caribbean fruit fly, *Anastrepha suspensa* (Loew), has a wide host range of over 80 species of fruits (Swanson & Baranowski 1972), but has not been reported to attack mamey sapote. There are records of *Anastrepha ludens* (Loew), *Anastrepha obliqua* (Macquart) and *Anastrepha serpentina* (Wiedemann) attacking mamey sapote in Central America (Emmart 1933; Norrbom & Kim 1988). While there are no records of *A. suspensa* attacking *P. sapota*, *A. suspensa* does attack *Pouteria campechiana* Baehni (the eggfruit or canistel), however these fruit have very thin rinds, and are soft, compared with *P. sapota*. Some of the data on these host lists are from laboratory studies, and the hosts are rarely attacked in the field (Norrbom & Foote 1989).

In summary, there is evidence that the Caribbean fruit fly attacks close relatives of the mamey sapote and close relatives of the Caribbean fruit fly attack the mamey sapote. The purpose of this research was to determine if the Caribbean fruit fly will attack the mamey sapote and infest it under field and laboratory conditions, and the relative severity of any infestations.

MATERIALS AND METHODS

Experiment 1, laboratory cage trials

In 1997 laboratory studies were conducted with several mamey sapote cultivars, Mangaña,

Pantin (Key West), Pace and Maya (Mayapan). Fruit were purchased or collected from groves of each cultivar in Dade County, Florida from April 10 through July 17, 1997. The fruit from each grove on each date were divided randomly into 3 groups with equal numbers of fruit in each group. One group of fruit was held without treatment to determine if any natural infestations were present. The other 2 groups of fruit were placed in cages ($1 \times 1 \times 1$ m) with 10 female and 10 male 10-day-old Caribbean fruit flies. The fruit in 1 of the treatments were punctured (25 pinholes 2-3 cm into the fruit) before placement into the fly cage to allow easier access for ovipositing fruit flies. In addition to these treatments, for each date that fruit were collected, 1 cage was prepared with 5 heat-disinfested guavas (35 minutes immersion in 46°C water) exposed to 10 female and 10 male 10-day-old fruit flies as a positive control.

After exposure to fruit flies for 24 h (under a photoperiod of 14:10 L:D) the fruit were removed from the cages and held 3 to 4 weeks at about 25°C. Any emerging larvae or pupae were collected and counted. At the end of the holding period, each fruit was opened and the pulp inspected for presence of larvae or pupae before disposal.

Experiment 2, field cage trials

In 1998 field tests were conducted with mamey sapote cultivars Magaña and Pantin. Three cooperators were selected for each cultivar and groves were visited every 2 weeks from April to September. Five mamey sapote fruit were individually bagged on the tree with 5 mated female fruit flies for 24 h. A control group of 4 guavas was individually bagged on the mamey sapote tree with 5 female fruit flies for 24 h to ensure that the flies were capable of laying eggs.

The fruit were enclosed in a 45×45 cm plastic bag with many small air holes (Delnet pollination bag, Applied Extrusion Technologies, Inc., Middletown, DE) supplied with water-soaked cotton and a sugar cube. The bag was secured to the tree and fruit with wire twist ties and rubber bands. A 23 cm diameter opaque plastic plate was placed above each bag to shield the fruit from rain and direct sun.

One group of 5 mamey sapote was collected and held without treatment to determine if a field infestation existed. Samples of fruit lying on the ground were also collected if available (some groves did not have any fallen fruit) and held to determine if they were infested. All fruit were then taken to the laboratory where size, weight, inner peel color and firmness were recorded.

Four glass McPhail traps were placed in each grove (1 on each side of the grove) at ¾ tree height in the exterior part of the tree canopy and baited with 10 g of torula yeast plus 300 ml of water. The traps were monitored for the presence of adult flies each week that the grove was sampled for fruit.

Results

Experiment 1, laboratory cage trials

A total of 396 mamey weighing a total of 237.6 kg were used in this experiment. Mean cultivar weights were Magaña 1,019.9 ± 36.3 g, Pantin 718.8 ± 28.0 g, Maya 603.4 ± 39.1 g, and Pace 468.7 ± 13.3 g. Mamey sapote fruit are very firm; pressure tests showed that while fruit firmness declined as the season progressed, it remained higher than -80 Newtons (the force required to push a 12 mm diameter cylinder into the fruit 3 mm; larger negative number = harder fruit) (Fig. 1). Guavas, which are primary hosts for Caribbean fruit flies, average about -30 Newtons when mature. Mamey sapotes, even at the end of the test period, were twice as firm as guavas.

No insects were recovered from any of the fruit held without treatment, therefore there was no natural infestation. The control guavas in every replicate had fruit fly larvae present. Only 1 of the treated replicates had fruit fly larvae in mamey sapote fruit. In the replication from 29 May 1997, 8 larvae were found from unpunctured Magaña mamey sapotes (3 fruit) exposed to female fruit flies, and 1 larva was recovered from punctured Magaña mamey sapotes (3 fruit) exposed to female fruit flies. The guava control (5 fruit) for that replication had 223 larvae, which was much higher than the larvae from control fruit in other replications (Table 1). The fruit from the 29 May 1997 test date showed no physical differences from fruit used on any of the other test dates.

Experiment 2, field cage trials

A total of 250 mamey sapotes weighing a total of 173 kg was used in this experiment. Magaña and Pantin were the two cultivars tested (weighing 882 ± 210 g and 617 ± 93 g, respectively). The fruit were firm, averaging harder than -100 Newtons throughout the season (Magaña -119 ± 17, Pantin -120 ± 11) (Fig. 2). The fruit collected from the ground (3.6 kg Magaña, 46.3 kg Pantin) were usually too soft to measure firmness, and were often split open with the pulp exposed. The number of fallen fruit varied greatly because some growers harvested all fruit or cleaned up fallen fruit. Other growers allowed fallen fruit to rot on the ground under trees.

No larvae were recovered from any of the mamey sapotes tested. No field infestation was found in either fruit on the trees or fruit recovered from the ground. No larvae were recovered from any mamey sapote bagged with female fruit flies. Almost all of the guava control fruit became infested, with larval numbers ranging up to 325 larvae recovered from 4 guavas (Table 2). Caribbean fruit fly adults were present in all of the groves used for the experiments. Fly populations

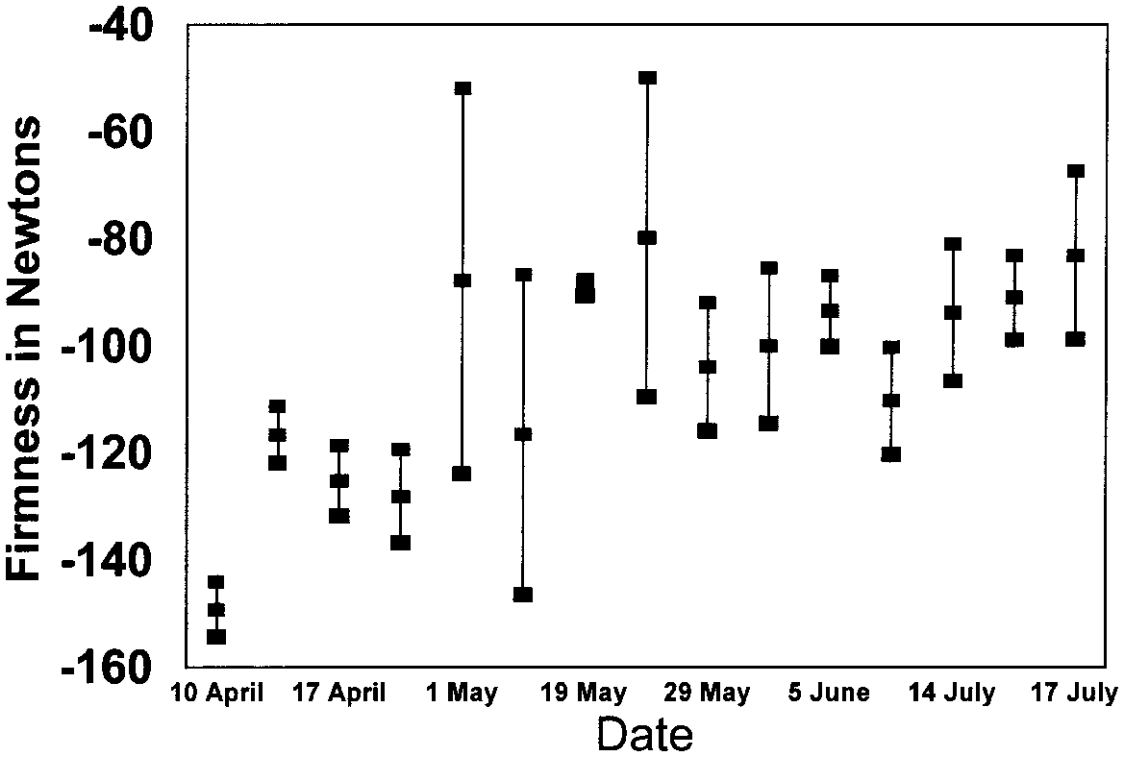

Fig. 1. Firmness of mamey sapote used in laboratory infestation tests in 1997 (the force in Newtons required to push a 12 mm diameter cylinder into the fruit 3 mm).

TABLE 1. NUMBERS OF MAMEY EXPOSED AND LARVAE RECOVERED, LABORATORY TEST 1997.

Date	Cultivar (number exposed)	Number of larvae found			
		Fruit exposed to flies in lab			
		Guavas	Intact mamey	Pinholed mamey	Control mamey
10 April	Maya (9)	1	0	0	0
	Pantin (9)	1	0	0	0
17 April[1]	Magaña (2)	—	—	—	0
	Pace (2)	—	—	—	0
	Pantin (3)	—	—	—	0
17 April	Magaña (9)	16	0	0	0
	Pace (15)	16	0	0	0
1 May	Magaña (9)	5	0	0	0
	Pace (15)	5	0	0	0
19 May	Magaña (9)	5	0	0	0
	Pace (15)	5	0	0	0
29 May	Magaña (9)	223	8	1	0
	Pace (15)	223	0	0	0
5 June	Pantin (90)	11	0	0	0
18 June	Pantin (12)	6	0	0	0
14 July	Pantin (12)	14	0	0	0
	Maya (12)	14	0	0	0
17 July[1]	Maya (150)	—	—	—	0

[1]Fruit held to determine if a natural infestation exists, not exposed to caged flies.

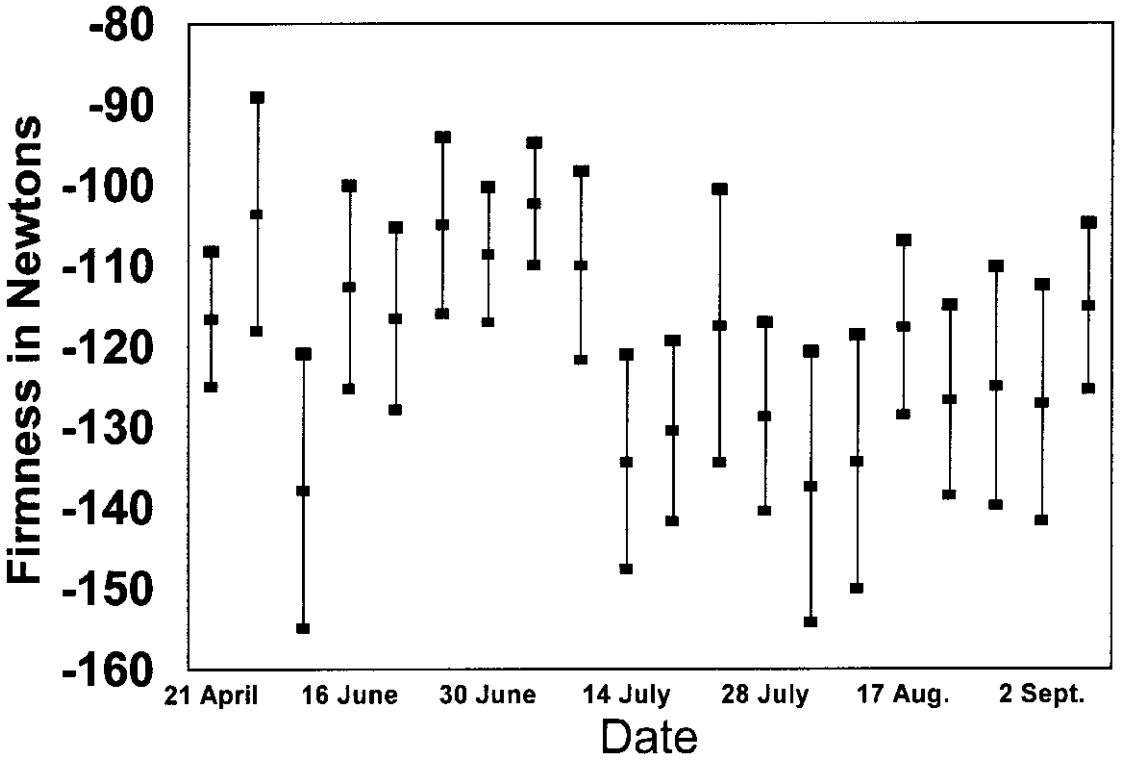

Fig. 2. Firmness of mamey sapote used in field infestation tests in 1998 (the force in Newtons required to push a 12 mm diameter cylinder into the fruit 3 mm).

were highest at the beginning and end of the sampling period (Fig. 3).

Discussion

The collection of fruit for the laboratory tests (1997) covered the commercial season for Magaña and the first half of the season for Pantin which make up 95-98% of the commercial acreage (Balerdi et al. 1996). Most of these fruit ripen during the period April through August. Often a few fruit are available at other times, however Caribbean fruit fly populations are also highest in the early summer (Hennessey 1994). In the laboratory study 9 larvae were recovered from mamey sapotes in 1 of the replications. The control infestations were highest at this time in the experiment (223 larvae). There were no physical differences found between the fruit that were infested and those that were not infested. The high oviposition

Table 2. Numbers of mamey exposed and larvae recovered, field test 1998.

Cultivar	Replication and dates	Number of larvae found (Mean ± SEM)		
		Guava (4 fruit)	Bagged mamey sapote (5 fruit)	Untreated control mamey sapote (5 fruit)
Magaña	R1, 21 Apr.-1 May	30.0 ± 15.3	0	0
	R2, 7 May-13 May	49.3 ± 32.3	0	0
	R3, 19 May-1 June	9.0 ± 9.0	0	0
Pantin	R1, 16 June	19.7 ± 4.8	0	0
	R2, 30 June	279.0 ± 46.0	0	0
	R3, 14-15 July	218.7 ± 45.9	0	0
	R4, 28-30 July	170.7 ± 11.7	0	0
	R5, 17 Aug.	66.3 ± 15.9	0	0
	R6, 2 Sept.	49.5 ± 8.5	0	0

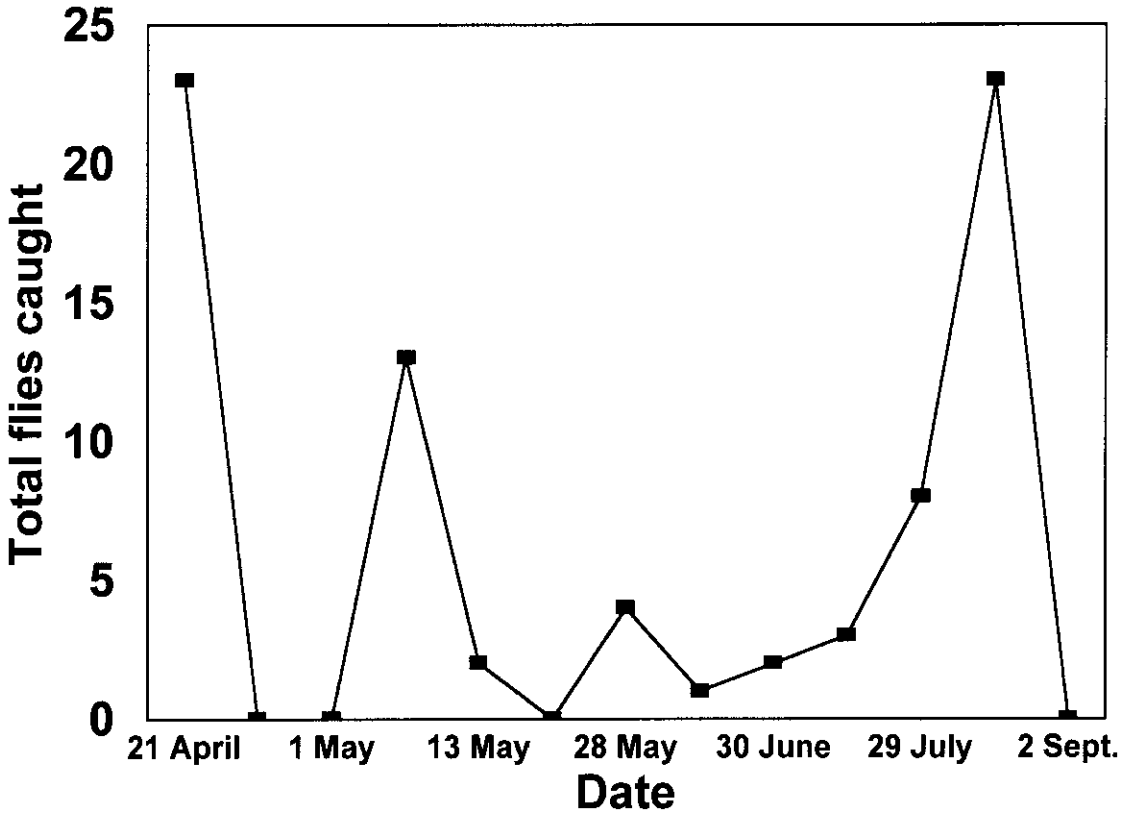

Fig. 3. Total numbers of adult Caribbean fruit flies trapped in field tests, 1998. Four McPhail traps per grove collected weekly.

pressure in this case may have overwhelmed the natural barriers to oviposition. The low number of larvae resulting indicates that the mamey sapote is a poor host under forced infestation.

The collection of fruit and tests done in the field (1998) covered the main harvest season for both varieties tested (Magaña and Pantin). Fruit fly populations were present in the fields, and the flies in the field cage tests produced thousands of larvae in the control guavas. No larvae were found in any of the field-collected fruit samples in either 1997 or 1998, and the cage tests did not produce any infestations in mamey sapotes. In addition none of the fruit which were collected from the ground, and which were often overripe and broken open, produced any fruit fly larvae.

Several fruit have been shown to be non-hosts for the Caribbean fruit fly. Based on Hennessey et al. (1992) and Nguyen & Fraser (1989), limes are not hosts to the Caribbean fruit fly. Limes and other citrus have biochemical defenses which cause mortality of eggs and small larvae (Greany et al. 1983). In this study we found that unripe mamey sapote had a distinct chemical odor and white latex juice present when cut. This suggests that chemical defenses to fruit fly infestation could be present in mamey sapote. Eggs and larvae placed on unripe mamey sapote slices had a high mortality rate (author unpublished data).

Using very high numbers of ovipositing fruit flies increases the likelihood of declaring a non-host a host, since many species of fruit may be infested under the pressure of hundreds of ovipositing females in a confined setting. Under field conditions it is likely that there are fewer than 5 flies visiting any given fruit.

'Forcing' larvae into ripe fruit under artificial conditions does not fairly represent field conditions. Therefore, under the protocol of Cowley et al. (1992), mamey sapote were tested to see whether they would be infested under caged conditions in the field, as well as collecting fruit for evidence of a natural infestation.

In the laboratory and field forced infestation tests, 5 female flies were used. This is probably much higher than the fly population any given fruit is naturally exposed to in the field, and it is more realistic than using hundreds of flies in a small cage. The only infestation that occurred was in a single replication in the laboratory and at a very low rate compared to the control fruit (9 larvae vs. 223 control larvae).

In this two year study, a balanced approach was used which included field and laboratory tests with as large a sample size as was realistic. The protocol of finding host status as proposed by Cowley et al. (1992) was used as a guide. Gould et al. (1999) found that lychees and longans were not hosts to Caribbean fruit flies using similar field and laboratory studies.

A total of more than 646 fruit of Magaña, Pantin, Pace, and Maya mamey sapote weighing in total more than 410 kg were exposed to Caribbean fruit flies either in the laboratory or under forced or natural field conditions. No Caribbean fruit fly larvae were recovered from any fruit collected in the field or exposed to caged flies in the field. In addition, no larvae were recovered from 50 kg of fruit (approximately 100 fruit) which was collected from the ground in the field, and which would be the most likely to have larvae if an infestation were present in mamey sapote.

Mamey sapote are very firm, normally being harvested when the fruit is harder than -80 Newtons. Guavas, one of the best hosts for Caribbean fruit fly, are much softer averaging -41.2 ± 7.1 Newtons (n = 10) when mature green. Guavas have a very strong odor while unripe mamey sapotes are almost odorless. Some fruit odors have been found to be powerful attractants for fruit flies (Robacker et al. 1990; Nigg et al. 1994). In addition there was evidence of chemical defenses to fruit fly infestation in unripe mamey sapotes.

Based on the protocol put forth by Cowley et al. (1992) and extensive laboratory and field tests, Magaña and Pantin mamey sapotes are not hosts to the Caribbean fruit fly in commercial mamey sapote groves and present no risk of transporting *A. suspensa* from Florida to other locations.

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